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Patentanmeldung Nr. Patent application No. Demande de brevet n°

03104890.3

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Method of scheduling broadcasts in a self-organizing network

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Method of scheduling broadcasts in a self-organizing network

FIELD OF THE INVENTION

This invention relates to a method of scheduling broadcasts in a self-organizing network, the method comprising the steps of transmitting a broadcast comprising presence information from a first device to its neighbouring devices in the self-organizing network every period T_B. The invention further relates to a device and a self-organizing network comprising devices.

BACKGROUND OF THE INVENTION

Self-organizing networks are networks in which a collection of devices, so-called nodes, with network interfaces may form a temporary network without the aid of any established infrastructure or centralized administration. The topology of the self-organizing network may change rapidly, especially in wireless networks of mobile devices, where the mobile devices are capable of moving. Typically, communication between two wireless nodes is only possible when the two nodes are within radio communication range. Existing examples of such self-organizing networks are Mobile Ad-hoc Networks (MANETs), Multi-hop cellular networks (MCN) or Personal Area Networks (PANs). Self-organizing wireless networks have immediate utility in a variety of industrial, medical, consumer and military applications.

Each node in the network periodically sends out a beacon, i.e. a broadcast comprising presence information. All nodes receiving this beacon consider the sending node as a neighbour and update a table of neighbouring nodes. Beacons are the default mechanism in finding neighbouring information for self-organizing devices. These beacons are periodic and are required to be transmitted periodically by each device. This helps each device in knowing the presence of new devices and to assess that current devices are still in its transmission range. However, transmitting these beacons is power and bandwidth consuming. A need for a method of scheduling the beacons in an efficient way exists and the object of the invention is to provide such a method.

The object is achieved, when the method mentioned in the opening paragraph is characterized in that the transmittal of a broadcast comprising presence information from

the first device is skipped if all its neighbours have received the broadcast from the first device during a period T_{CB}. This provides a way of skipping broadcasts without loosing information regarding the neighbouring devices of a first device. When broadcasts or beacons can be skipped, the power consumption in the devices and the bandwidth consumption can be reduced. Moreover, collisions between transmitted broadcasts can be reduced by the method of the invention. The self-organizing network may be wired, wireless, or a combination thereof. A device in the network may be mobile or stationary.

Preferably, the first device in the self-organizing network keeps a list of those devices, which are its neighbouring devices. Thus, the devices in the self-organizing network keep track of their current neighbouring devices. The list of neighbouring devices typically is used both in checking if new devices have entered the network and if devices have left.

Preferably, the transmittal of the broadcast comprising presence information from the first device is skipped during a second part of the period T_{CB} if all its neighbours have received the broadcast from the first device during a first part of period T_{CB}.

In a preferred embodiment, the broadcast comprising presence information transmitted from a device further comprises information regarding whether the device has received a broadcast from each device in a list of neighbouring devices. This provides a way of determining when to skip a broadcast without loosing information regarding the presences of neighbouring devices. The information regarding whether the device has received a broadcast from each device in its list of neighbouring devices can be in the form of a bit in the broadcast comprising presence information, which bit is set under certain conditions (see for example below) and which bit indicates, to the receiving neighbouring devices, whether said neighbouring devices should skip a broadcast or not.

Preferably, $T_B < T_{CB}$. T_B is the beacon period, i.e. the time between broadcasts comprising presence information transmitted from a device in the self-organizing network, and T_{CB} is the check beacon period, i.e. the time between every check for reception of broadcasts from neighbouring devices. The beacon period preferably is equal for each device in the network; however, the beacon periods for the different devices typically are not synchronized. The same applies for the check beacon period. It should be noted, that the device detects reception of beacons substantially continuously, but the checking of reception of broadcasts from neighbouring devices at the check beacon period T_{CB} identifies which devices currently are neighbouring devices.

In yet a preferred embodiment, $T_{CB} = N^*T_B$,, where N R When $T_{CB} = N^*T_B$, the beacon checking is synchronized with the beacon transmission, which helps in maintaining correct neighbouring information for protocols that use a two-hop topology. Preferably, N equals 2, 3 or higher numbers.

It is preferred that a broadcast comprising presence information transmitted from the device comprises a *skip beacon bit*, which is set if the following conditions are both met:

- $(t_{CB(i), next} - t) > T_B$;
- a broadcast comprising presence information has been received from each device in the list of neighbouring devices in current T_{CB},

where $t_{CB(i), next}$ is the next instant in time, where the device is arranged to check from which devices it has received broadcasts comprising presence information and t is the current time. This gives a precise indication of the conditions for setting a *skip beacon bit*, which is a bit indicating to the receiving stations, whether they might skip the next broadcast otherwise scheduled.

Preferably, a device will skip a broadcast if the following conditions are both met:

- all broadcasts comprising presence information from devices in the list of neighbouring devices in the current period T_{CB} have the *skip beacon bit* set;
- . $(t_{CB(j), next} - t) > T_B$,

where $t_{CB(j), next}$ is the next instant in time, where the device is arranged to check from which devices it has received broadcasts comprising presence information and t is the current time.

These conditions give, together with the above two conditions, a precise indication of whether a station can skip a broadcast.

In yet a preferred embodiment, the broadcast comprising presence information transmitted from a first device further comprises a list of neighbouring devices of the first device. This facilitates routing in a two hop topology. When a device receives a broadcast comprising presence information, it derives the sender as its neighbour and the devices in the list as devices which can be reached through the transmitting device in the two-hop topology. Conditions regarding when to set a *skip beacon bit* in the broadcasts and when a device should skip a broadcast similar to the above conditions are drawn up below. The above can be extended to other multi-hop topologies as well.

In yet a preferred embodiment of the method according to the invention, a device will skip a broadcast if ($t_{CB(j),\,next} - t$) > T_B, and if one of the following conditions is met:

- all broadcasts comprising presence information from devices in the list N_j of neighbouring devices in the current period T_{CB} have the *skip broadcast bit* set

OR

- all broadcasts comprising presence information received from devices in M_k, where M_k T N_j, during the current check beacon period have the *skip broadcast bit* set AND the devices in $N_j \backslash M_k$ is not in the "LAST_KNOWN_BEACON" field of any of the broadcasts transmitted from the devices in the list M_k,

where the "LAST_KNOWN_BEACON" field indicates from which device a broadcast comprising presence information has been received at the earliest during the current check beacon period T_{CB}; $t_{CB(i),\,next}$ is the next instant in time, where the device *i* is arranged to check from which devices it has received broadcasts comprising presence information; and t is the current time. M_k is a subset of the list N_j of neighbouring devices; thus M_k is a list of some of the neighbouring devices of the device *j*. $N_j \backslash M_k$ is the remainder of N_j, i.e. a list of the devices which are in N_j, but not in M_k.

This preferred embodiment provides a further optimization in power and bandwidth consumption in that it provides a way of transmitting even less broadcasts comprising presence information, i.e. beacons, without loosing information.

It should be noted that the term "beacon" is meant to cover any broadcast indicating the presence of a device, possibly also containing a list of the neighbours of said device. Moreover, it should be noted that the terms *skip broadcast bit* and *skip beacon bit* are used synonymously in this specification.

It should furthermore be noted that the devices in the self-organizing network could be similar types of devices or different types of devices; the essential feature of the self-organizing network in which the method could be used, is that the devices should be able to transmit and receive broadcasts to and from each other. However, preferably the devices in the self-organizing network should be able to exchange other types of information.

OBJECT AND SUMMARY OF THE INVENTION

The invention will be explained more fully below in connection with a preferred embodiment and with reference to the drawing, in which:

Fig. 1 shows a self-organizing network;

Fig. 2 to 3 show two examples of the timing of the broadcasts from the nodes in a self-organizing network; and

Fig. 4 shows an example of the timing of the broadcasts from the nodes in a self-organizing network, where the broadcasts comprises a list of neighbouring mobile devices.

Fig. 1 shows a self-organizing network 100 with four nodes A, B, C and D. The term "node" is a mobile device (i, j) present in the self-organizing network 100. An arrow between two nodes indicates that said nodes are able to communicate with each other. Typically, this means that said nodes are in radio communication range of each other and capable of exchanging information between each other.

The node A has three neighbours, viz. B, C and D; the nodes B and C, respectively, have each two neighbours, in that the node B has the neighbours A and C and the node C has the neighbours A and B. Finally, the node D has only one neighbour, viz. A. This self-organizing network 100 is used as the basis of figs. 2-4.

Fig. 2 shows an example of the timing of the broadcasts from the nodes in the self-organizing network 100 shown in fig. 1. The broadcasts comprise presence information and are sent from any node in the self-organizing network 100 to its neighbouring mobile devices. Such a broadcast is called a beacon. A beacon is sent from each node, i.e. mobile device, in the network periodically.

The horizontal lines in fig. 2 indicate the time in seconds corresponding to the numbers in the top of the figure. The vertical lines indicate instants of transmitting beacons, the vertical lines with rectangles correspond to instants of checking for reception of broadcasts from neighbouring nodes and the vertical lines substantially surrounded by circles corresponds to instants where a beacon can be skipped according to the method of the invention.

As noted above, the beacon period T_B is equal for each mobile device in the network; however, the beacon periods for the different mobile devices typically are not synchronized, so that the instants of transmitting a beacon is different for the different nodes. The same applies for the check beacon period T_{CB}.

The time between broadcasts containing presence information, i.e. the beacon period T_B, is the same for each node and equals 2 seconds in fig. 2. The time between every

check for reception of broadcasts from neighbouring nodes is the check beacon period T_{CB}, which in fig. 2 equals 4 seconds.

The beacon period T_B and the check beacon period T_{CB} are synchronized for each node, so that the instants of checking received beacons coincides with instants of transmitting beacons for each node. However, in fig. 2 node A, B, C and D, respectively, starts transmitting beacons shifted in time, so that node A starts transmitting beacons at the time 1 second, node B at the time 1.5 second, node C at the time 2 seconds and node D at the time 2.5 seconds.

After beacon transmission by every neighbouring node, each node has knowledge of its neighbours, i.e. its neighbouring topology. For example node A knows that it has the three neighbours, B, C and D. Node B and C know of their two neighbours and node D knows about its neighbour A.

It is assumed that the neighbouring topology of the nodes A, B, C and D remains stable for the shown period (1 to 16.5 seconds); this helps maintaining correct neighbouring information for use in two-hop topology. In a two-hop topology, each node *i* keeps an updated list N_i of its neighbouring nodes. After beacon checking at the node *i*, the correct list N_i is known and can be transmitted together with the next scheduled beacon to be used in a two-hop or in other multi-hop topologies.

In the following, it will be explained when a scheduled beacon can be skipped according to the method of the invention. When a node receives a beacon from all its neighbouring nodes long before the time for it to check the received beacons, the node informs its neighbours to skip their scheduled beacons under the condition that the have also received beacons from all their other neighbouring nodes in their current check beacon period. As mentioned above, the mobile device detects reception of beacons substantially continuously, but the checking of reception of broadcasts from neighbouring mobile devices at the check beacon period T_{CB} identifies which mobile devices currently are neighbouring mobile devices.

If t is the current time for a node *i*, N_i is the neighbour list of the node *i*, and $t_{CB(i),next}$ is the next instant in time, where the node *i* is arranged to check from which mobile devices it has received broadcasts comprising presence information and T_B denotes the beacon period, the conditions for a node to set a *skip beacon bit* to be transmitted together with its subsequent beacon are:

- $(t_{CB(i),\,next} - t) > T_B$ (1)

- a broadcast comprising presence information has been received from each mobile device in the list N_i of neighbouring mobile devices in current T_{CB} (2)

A node *j* will skip its subsequent beacon transmission if:

- all broadcasts comprising presence information from mobile devices in the list N_j of neighbouring mobile devices in the current period T_{CB} have the *skip beacon bit* set (3)
- $(t_{CB(j),\,next} - t) > T_B$ (4)

where t is the current time and $t_{CB(j),next}$ is the next instant in time, where the node *j* is arranged to check from which mobile devices it has received broadcasts comprising presence information.

In the following, the time between two check beacon instants of node A, e.g. the time between 5 and 9 seconds, are considered. Shortly after the time 6.5 seconds node A has received beacons from each neighbouring node, so conditions (1) and (2) above are satisfied. Therefore node A can set the *skip beacon bit* in its beacon and transmit the beacon together with the *skip beacon bit* at the time 7 seconds. After a short time span (due to the transmission time between the neighbouring nodes) the nodes B, C and D receive the beacon from node A containing a set *skip beacon bit*. Said nodes will check the conditions (3) and (4) above to check if they can skip their subsequent scheduled beacon. Condition (3) is not satisfied for node B, in that it has not received a beacon from node C containing a set *skip beacon bit*. Both conditions, (3) and (4), are satisfied for the nodes C and D; thus, they will skip their scheduled beacon at the instants 8 seconds and 8.5 seconds respectively. This is indicated in fig. 2 as the vertical lines surrounded by circles at the instant 8 seconds on the time line for the node C and at the instant 8.5 seconds on the time line for node D. As indicated in fig. 2, one half of the scheduled beacons of the nodes C and D can be skipped. It can be seen in fig. 2, where $T_{CB} = 2*T_B$, that 8/32 = 25% of the scheduled beacons can be skipped.

Fig. 3 shows an example of the timing of the broadcasts from the nodes in a self-organizing network. As in fig. 2, the horizontal lines indicate the time in seconds corresponding to the numbers in the top of the figure. The vertical lines indicate instants of transmitting beacons, the vertical lines with rectangles correspond to instants of checking for reception of broadcasts from neighbouring nodes and the vertical lines substantially surrounded by circles corresponds to instants where a beacon can be skipped according to the method of the invention.

Again, the time between broadcasts containing presence information, i.e. the beacon period T_B, is the same for each node and equals 2 seconds in fig. 3. The time between

every check for reception of broadcasts from neighbouring nodes is the check beacon period T_{CB}, which in fig. 3 equals 6 seconds.

The conditions (1) – (4) above for setting *skip beacon bit* and for skipping a beacon are as explained in connection with fig. 2.

From fig. 3 it is clear, that a larger percentage of beacons can be skipped. This is due to the fact, that check beacon period T_{CB} in fig. 3 equals $3*T_B$, so that conditions (1) and (4) more often are satisfied compared to when $T_{CB} = 2*T_B$ as in fig. 2. In fig. 3 10/32 = 31% of the beacons can be skipped compared to traditional scheduling.

In the following, it is explained how the method of the invention works, if a new node joins the self-organizing network and if a current node moves away from the self-organizing network.

Assume that a new node E has joined the self-organizing network and is only a neighbour of nodes A and C. Node A has knowledge of new nodes in the network only when it checks the beacons received at the check beacon instants. So the node A will set the *skip beacon bit* in a beacon, as described above, only when it has received a beacon from all its neighbours in the current check beacon period (conditions (1) and (2)).

If the node C is about to skip the next scheduled beacon (conditions (3) and (4) are satisfied), but receives a beacon from the newly joined node E, the node C cannot skip the next scheduled beacon in that the beacon received from node E does not have a *skip beacon bit* set (condition (3)); condition (3) in this case makes sure that the node C indicates its presence to the new neighbouring node E.

Assume that the self-organizing network consists of the nodes A, B, C and D shown in fig. 1 and that the node C is leaving the network.

The condition (2) for skipping beacons from the remaining nodes in the network is that a beacon should be received from each of the nodes in the list N_i. Two situations can occur: (a) the node C leaves the network without sending a beacon in the current cycle (T_{CB})) of the nodes A and B, and (b) the node C leaves immediately subsequent to sending a beacon in the current cycle (T_{CB})) of the nodes A and B.

In the situation (a) the nodes A and B can not be able to set the *skip beacon bit*, since they have not received the beacon from each of their neighbours (i.e. condition (2) is not satisfied). Therefore, the nodes receiving beacons from nodes A and B cannot skip their subsequent beacons, since condition (3) is not satisfied.

In the situation (b) the nodes A and B have received a beacon from the node C, and if they receive beacons from other neighbours too, they set the *skip beacon bit* in their

next beacon. The only way a node has knowledge to a node movement is after the current check beacon period, in that it has already received the beacon during the current check beacon period.

Fig. 4 shows an example of the timing of the broadcasts from the nodes in a self-organizing network, where the broadcasts comprises a list of neighbouring mobile devices. As in figs. 2 and 3, the horizontal lines indicate the time in seconds corresponding to the numbers in the top of the figure. The vertical lines indicate instants of transmitting beacons, the vertical lines with rectangles correspond to instants of checking for reception of broadcasts from neighbouring nodes and the vertical lines substantially surrounded by circles corresponds to instants where a beacon can be skipped according to the method of the invention.

Again, the time between broadcasts containing presence information, i.e. the beacon period T_B, is the same for each node and equals 2 seconds in fig. 4. The time between every check for reception of broadcasts from neighbouring nodes is the check beacon period T_{CB}, which in fig. 4 equals 4 seconds.

Fig. 4 illustrates the skip beacon mechanism for nodes in a two-hop topology. In figs. 2 and 3, each beacon contains the sender address of the node transmitting the beacon; in fig. 4 each beacon moreover contains the list N_i of neighbouring nodes of the node *i*. Furthermore, each beacon contains a field "LAST_KNOWN_BEACON" indicating which node has sent a beacon at the earliest during the current check beacon period. With other words, the field "LAST_KNOWN_BEACON" indicates from which node a beacon has been received at the earliest during the current check beacon period T_{CB}.

At the instant 7 seconds, the field "LAST_KNOWN_BEACON" of the node A equals "B", since B is the first node having transmitted a beacon to A (at the instant 5.5 seconds). Similarly, for node B, "LAST_KNOWN_BEACON" equals "C", etc.

When node A transmits a beacon at the instant 7 seconds, it has the *skip beacon bit* set (as explained above). The nodes C and D skip their subsequent beacons of the reasons explained in relation to fig. 2. Moreover, the node B skips its subsequent scheduled beacon (scheduled at the instant 9.5 seconds) with the help of the field "LAST_KNOWN_BEACON" and with two-hop topology.

For example, the beacon sent from node A at the instant 7 seconds contains the list N_A of the neighbouring nodes of node A together with the field "LAST_KNOWN_BEACON". The list N_A contains the nodes B, C and D and the field "LAST_KNOWN_BEACON" equals "B". With this information the node B can derive that

the nodes C and D can be reached through the node A and that they each have transmitted a beacon to node A after the preceding transmittal of the beacon at the instant 5.5 seconds.

With this the condition (3) above can be changed to the following:

- all broadcasts comprising presence information from mobile devices in the list N_j of neighbouring mobile devices in the current period T_{CB} have the *skip beacon bit* set (3a)

OR

- all beacons comprising presence information received from mobile devices in M_k, where M_k T N_j, during the current check beacon period have the *skip beacon bit* set AND the mobile devices in $N_j \backslash M_k$ is not in the "LAST_KNOWN_BEACON" field of any of the beacons transmitted from the mobile devices in the list M_k. (3b)

where M_k is a subset of the list N_j of neighbouring nodes; thus M_k is a list of some of the neighbouring nodes of the node *j*. $N_j \backslash M_k$ is the remainder of N_j, i.e. a list of the nodes which are in N_j, but not in M_k.

The conditions (1), (2), and (4) are kept unchanged. It can be seen, that the condition (3a) equals the former condition (3), so that alternative condition (3b), i.e. the inclusion the field "LAST_KNOWN_BEACON", can be used to skip additional beacons.

In fig. 4, i.e. when the check beacon period T_{CB} equals $2*T_B$ and when the beacons contain list of neighbouring nodes, 12/32 = 37.5 % of the scheduled beacons can be skipped.

For the sake of clarity, the figures have all been related to a self-organizing network comprising only four nodes. However, the conclusions of the above can be extended to networks comprising larger numbers of nodes. Thus, in general, the percentage of beacons, which can be skipped, is increased as T_{CB} is increased in relation to T_B.

Above, it was explained how the method of the invention worked, if a new node joins the self-organizing network and if a current node moves away from the self-organizing network without the use of the neighbouring lists. The method can be arranged to check the neighbouring list at each node after every beacon received, which can give rise to the knowledge of a new node entering the network or a current node leaving the network in the current beacon period instead of during the next beacon period. However, this typically causes the processing power in the nodes to increase substantially, if the number of neighbours is large.

While the invention has been described in connection with preferred embodiments, it will be understood that modifications thereof within the principles outlined

above will be evident to those skilled in the art, and thus the invention is not limited to the preferred embodiments but is intended to encompass such modifications. The invention resides in each and every novel characteristic feature and each and every combination of characteristic features. Reference numerals in the claims do not limit their protective scope. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements other than those stated in the claims. Use of the article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

The invention can be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. 'Computer program' is to be understood to mean any software product stored on a computer-readable medium, such as a floppy disk, downloadable via a network, such as the Internet, or marketable in any other manner.

CLAIMS:

1. A method of scheduling broadcasts in a self-organizing network (100), the method comprising the steps of:

- transmitting a broadcast comprising presence information from a first device to its neighbouring devices in the self-organizing network every period T_B,

characterized in that the transmittal of a broadcast comprising presence information from the first device is skipped if all its neighbours have received the broadcast from the first device during a period T_{CB}.

2. A method according to claim 1, characterized in that the transmittal of the broadcast comprising presence information from the first device is skipped during a second part of the period T_{CB} if all its neighbours have received the broadcast from the first device during a first part of period T_{CB}.

3. A method according to claim 1, characterized in that a broadcast comprising presence information transmitted from a device further comprises information regarding whether the device has received a broadcast from each device in a list of neighbouring devices.

4. A method according to claim 3, characterized in that the broadcast transmitted from the device comprises a *skip broadcast bit*, which is set if a broadcast comprising presence information has been received from each device in the list of neighbouring devices in current T_{CB}.

5. A method according to claim 4, characterized in that the broadcast transmitted from the device comprises a *skip broadcast bit*, which is set if the following conditions are both met:

- $(t_{CB(i),\,next} - t) > T_B$;
- a broadcast comprising presence information has been received from each device in the list of neighbouring devices in current T_{CB},

where $t_{CB(i),\,next}$ is the next instant in time, where the device is arranged to check from which devices it has received broadcasts comprising presence information and t is the current time.

6. A method according to claim 4, characterized in that the device will skip a broadcast if all broadcasts comprising presence information from devices in the list of neighbouring devices in the current period T_{CB} have the *skip broadcast bit* set.

7. A method according to claim 6, characterized in that the device will skip a broadcast if the following conditions are both met:

- all broadcasts comprising presence information from devices in the list of neighbouring devices in the current period T_{CB} have the *skip broadcast bit* set;
- $(t_{CB(j),\,next} - t) > T_B$,

where $t_{CB(j),\,next}$ is the next instant in time, where the device is arranged to check from which devices it has received broadcasts comprising presence information and t is the current time.

8. A method according to claim 4, characterized in that a device will skip a broadcast if $(t_{CB(j),\,next} - t) > T_B$, and if one of the following conditions is met:

- all broadcasts comprising presence information from devices in the list N_j of neighbouring devices in the current period T_{CB} have the *skip broadcast bit* set

OR

- all broadcasts comprising presence information received from devices in M_k, where M_k T N_j, during the current check beacon period have the *skip broadcast bit* set AND the devices in $N_j \backslash M_k$ is not in the "LAST_KNOWN_BEACON" field of any of the broadcasts transmitted from the devices in the list M_k,

where the "LAST_KNOWN_BEACON" field indicates from which device a broadcast comprising presence information has been received at the earliest during the current check beacon period T_{CB}; $t_{CB(i),\,next}$ is the next instant in time, where the device is arranged to check from which devices it has received broadcasts comprising presence information; and t is the current time.

9. A method according to claim 1, characterized in that $T_B < T_{CB}$.

10. A method according to claim 9, characterized in that $T_{CB} = N^*T_B$, where N R

11. A device performing the method according to claim 1.

12. A self-organizing network comprising devices performing the method according to claim 1.

13. A computer program product comprising a program of computer instructions for making a programmable computer perform the method according to claim 1.

ABSTRACT:

In self-organizing networks, broadcasts comprising presence information, so-called beacons, are the default mechanism in finding neighbouring information, i.e. information regarding which devices are present in the network of a given device. Such beacons are transmitted periodically from each device. A device has knowledge of the presence of other devices in the network when it receives beacons from them. The method of the invention suggests that a device could skip its subsequent scheduled beacon if all its neighbouring devices have received a previous beacon during the same period.

Figure 2

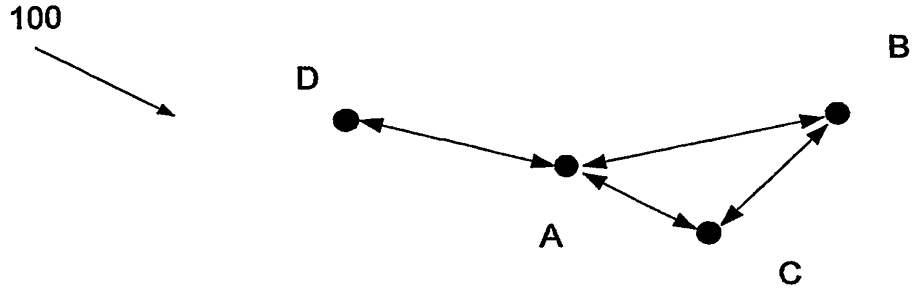

Fig. 1

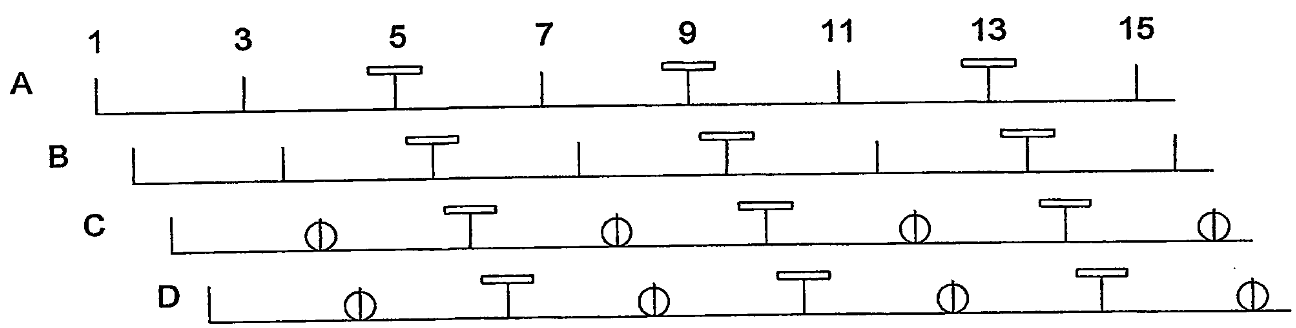

Fig. 2

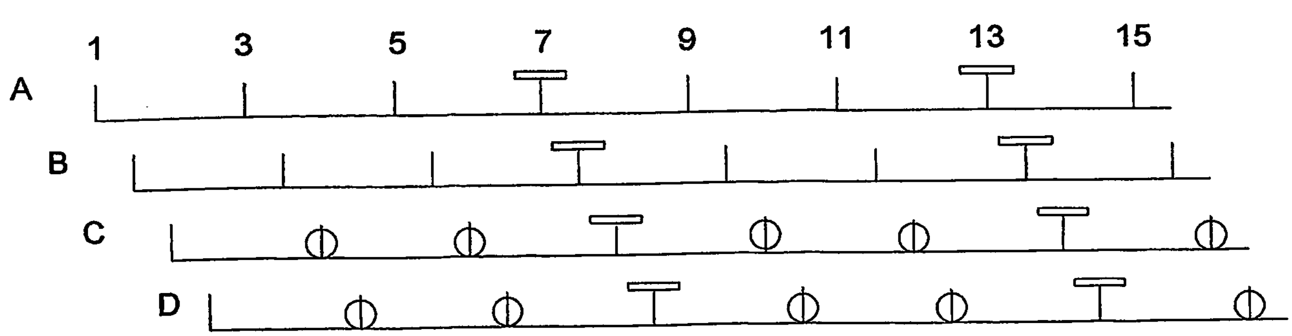

Fig. 3

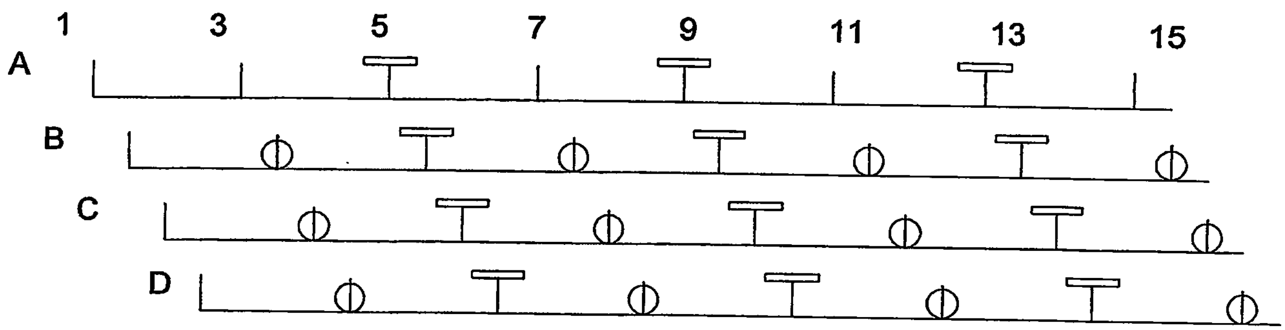

Fig. 4

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